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FUSTIC WOOD:

ITS SUBSTITUTES AND ADULTERANTS.

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FUSTIC WOOD: ITS SUBSTITUTES AND ADULTERANTS.

Buyers of fustic wood are often in doubt regarding the genuineness of some of the material put upon the market as true fustic. A microscopic study of a large number of samples of so-called fustic wood submitted to the Forest Service showed that several different woods are substituted for true fustic, or are used to adulterate it in a chipped or ground condition. The purpose of this circular therefore is to point out the distinguishing characteristics of genuine fustic wood and of its substitutes, in order that consumers may readily distinguish the real from the spurious article.

TRUE FUSTIC WOOD.

True fustic wood which yields the valuable yellow, brown, and green dyestuffs, comes from the fustic tree (*Chlorophora tinctoria* Gaud. = *Maclura tinctoria* D. Don = *Morus tinctoria* L), a native of the West Indies and tropical America. The tree is also called old fustic, fustic mulberry, Cuba wood, yellowwood, and mora. It should not be confused, however, with the true mora (*Dimorphandra mora* B. and H. = *Mora excelsa* Benth.) of British Guiana, Venezuela, and part of Central America, the wood of which is readily distinguished from that of freshly cut fustic by its reddish-brown color. The fustic tree attains a height of from 25 to 50 feet, and a diameter of 2 feet or more. The nearly white sapwood is very thin, and the greater portion of the tree therefore is heartwood, the only part put to commercial use. Freshly cut heartwood is light yellow, but after exposure to air and light becomes a yellowish brown. A cubic foot of seasoned wood weighs approximately 50 pounds.

Most of the fustic wood used in Europe comes from South America, while the bulk of that consumed in the United States comes from Mexico and the British West Indies. The amount entered at United States ports for immediate consumption during the year ending June 30, 1909, together with the withdrawals from warehouses for later use, was 2,466 tons, valued at $34,752. The average value per ton for 1909 was $14.09, an increase over the previous year of $1.99.

Fustic wood is usually imported in sticks from 2 to 4 feet long and from 3 to 8 inches in diameter, but appears also in the form of chips, powder, aqueous extract, and paste or lake. The greater part of the supply, however, comes on the market in either chips or large pieces. While it is possible with a microscope to detect fibers of other woods mixed with ground fustic, it is often impossible, from the fibers alone, to identify them, because the distinguishing characters of the fibers have been obliterated by grinding. It is comparatively easy, however, to identify the different woods before they are powdered or ground into pulp.

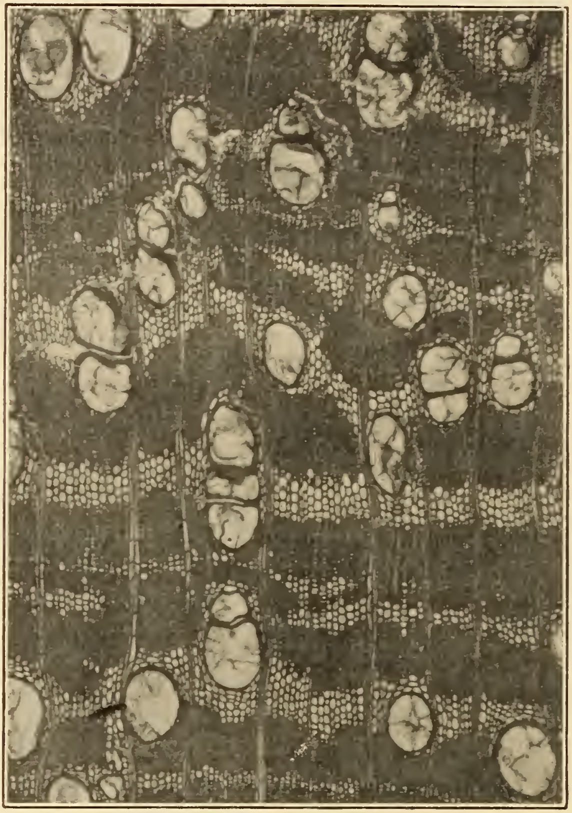

FIG. 1.—Transverse section of fustic wood (*Chlorophora tinctoria*). Magnified 50 diameters. *Vessels* are the large circular or elliptical openings scattered throughout the transverse section. *Wood fibers* comprise the broad, dark, dense, bands extending horizontally across the illustration. *Wood-parenchyma fibers* form the lighter, narrow, horizontal bands which extend across the picture; this tissue is seen to extend more or less around all vessels. *Pith rays* are the somewhat indistinct, narrow lines extending from the top to the bottom of the illustration.

SUBSTITUTES FOR FUSTIC WOOD.

The woods most commonly substituted for fustic are of the smoke-tree, osage orange, and also several species of prickly ash (*Xanthoxylum*), the latter being occasionally sold under the names prickly yellowwood or yellowwood. Since true fustic is becoming scarce, substitution of other woods is likely to be practiced even more extensively in the future than at present. Manufacturers of coloring extracts derived from fustic are now forced to compete with the manufacturers of extracts from similar dyewoods prepared by the synthetic process, and the small margin of profit on the genuine extract increases the temptation to substitute cheaper woods.

SMOKE-TREE.

(*Cotinus cotinus* (L.) Sarg.)

The wood of the smoke tree, an Old World species, was formerly sold as the young branches of old fustic, and therefore was often called young fustic. It is known also as Aaron's beard, false fringe tree, Venetian sumach, wigtree, young mastic, and Hungarian fustic. It is a large shrub or small tree, yielding sticks from 4 to 6 feet long and seldom over 4 inches in diameter. The heartwood, which is golden yellow, lustrous, and hard, gives a yellow dye for wool and leather. Most of this wood comes from Greece and other Mediterranean countries. The available supply, however, is limited.

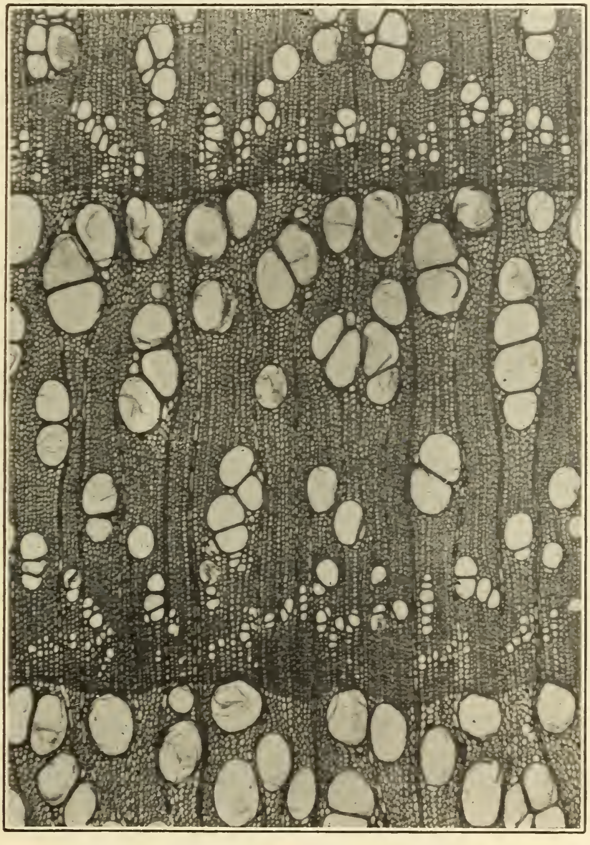

FIG. 2.—Transverse section of smoke-tree wood (*Cotinus cotinus*). Magnified 50 diameters.

A comparison of transverse sections of smoke-tree and fustic wood (figs. 1 and 2) clearly distinguishes one from the other. Instead of being diffuse porous [1] with indistinct annual layers of growth, as old fustic, smoke-tree wood is ring porous [2] and has distinct annual layers of growth with a preponderance of large pores in the early wood (inner part of the layer), which gradually diminish in number and size toward the outside of the layer. In smoke-tree wood the vessels and tracheids have large simple pits,[3] side by side, together with transitional forms merging into true bordered pits,[3] but never bordered pits alone. The markings on the walls of vessels in true fustic consist of round bordered pits only. The simple pits in the vessels of smoke-tree are in most cases elliptical, lying parallel to one another, and transversely to the longitudinal axis of the elements, so that collectively they resemble the scalariform perforations of vessels. The wood fibers of the smoke-tree vary from 0.60 to 0.94 millimeter [4] in length, with an average of 0.78 millimeter, about 0.15 millimeter shorter than those of fustic.

OSAGE ORANGE.

(*Toxylon pomiferum* Raf.)

Osage orange is known also as osage, bois d'arc, bodock, bowwood, yellowwood, and hedge tree, and is native to the rich bottom lands of southern Arkansas and westward to Oklahoma and Texas. It has been planted extensively throughout the eastern and central United States, and is largely cultivated for hedges. By some it is claimed to be superior to fustic as a dyewood. The wood, which is yellowish, hard, heavy, and strong, is distinctly ring-porous and may readily be distinguished from that of smoke tree and true fustic by the conspicuous tangential bands of wood-parenchyma tissue near the outer boundaries of the layers of growth (fig. 3). The early wood begins with a more or less broad zone of greatly flattened wood-parenchyma fibers, among which are scattered large pores. The pores toward the outside of the annual ring of growth are very small and are within the tangential bands of wood-parenchyma fibers that

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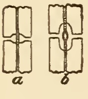
[1] In a diffuse-porous wood the pores are approximately the same size throughout the annual layers of growth and quite evenly distributed; this results in a wood of homogeneous structure, such as is shown in figures 1 and 4.

[2] In a ring-porous wood the pores are largest and most numerous in that portion of the annual layer of growth first formed; as a result, the annual layers are sharply defined, as seen in figures 2 and 3.

[3] Pits are unthickened portions in the walls of wood elements. They are either round, elliptical, or slitlike, and are further divided into simple and bordered pits. Whether a pit is simple or bordered is determined by the character of the canals which extend from the middle lamella, or common wall of two adjacent elements, to the cavity of the cell. When a transverse or longitudinal section is prepared, a so-called profile view of pits will be seen, and if the walls of the canal are nearly parallel or diverge only slightly toward the common wall, as shown in figure *a*, it is a simple pit. If the walls of the canal make a distinct angle just inside the pit opening, as shown in figure *b*, it is known as a bordered pit.



[4] A millimeter is about one twenty-fifth of an inch.

are not radially flattened. The wood fibers have thick walls, small cavities, and vary in length from 0.714 to 1.008 millimeters, with an average length of 0.865 millimeter, which is intermediate between smoke-tree and true fustic. The wood of this species (fig. 2) presents an entirely different arrangement of structural elements from that of either smoke-tree or true fustic, and there should be no difficulty in distinguishing the three species if smooth transverse cuts are viewed with a hand lens magnifying 6 or 8 diameters.

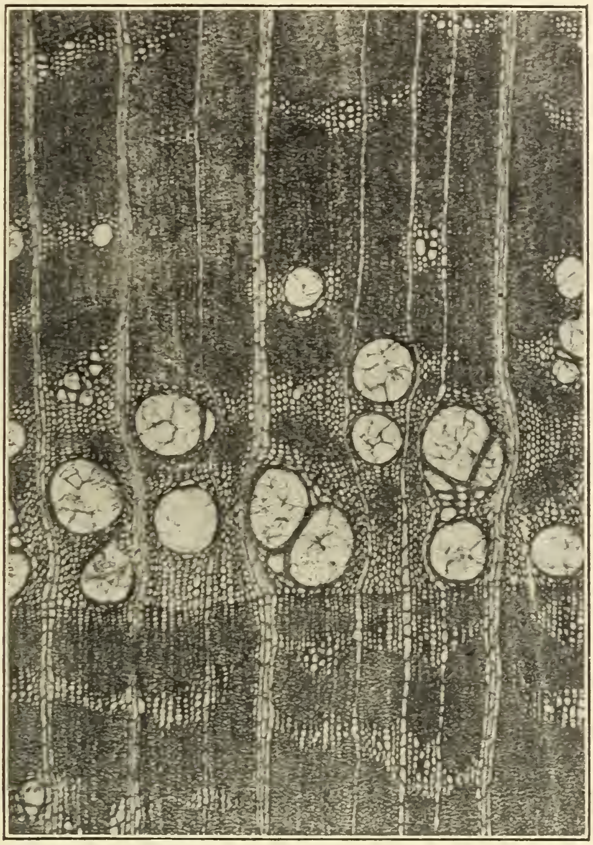


FIG. 3.—Transverse section of osage orange (*Toxylon pomiferum*). Magnified 50 diameters.

SOUTHERN PRICKLY ASH.

(*Xanthoxylum clava-herculis* Linn.).

Besides southern prickly ash, which ranges from southern Virginia to Florida and westward to Texas, the woods of the following species of semitropical Florida and the West Indies have appeared as substitutes for fustic: Espino (*Xanthoxylum acuminatum* Swartz), yellowwood (*X. ochroxylum* D. C.), satinwood (*X. cribrosum* Spreng.), and wild lime (*X. fagara* Linn. Sarg.). In the West Indies these woods are known by the general name of espino or espino rubial. Elsewhere they are known as box, yellow thorn, or yellow Hercules club. They furnish a hard, light yellowish wood, sometimes nearly white, but which becomes yellowish when exposed to light. The structural characters of the woods of these species are so similar that the southern prickly ash may be taken as typical of all.

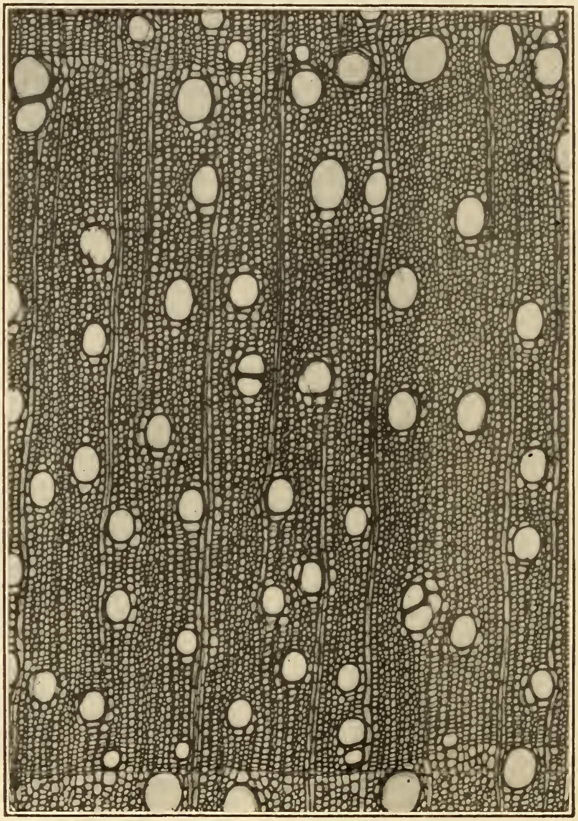


FIG. 4.—Transverse section of southern prickly ash wood (*Xanthoxylum clavaherculis.*) Magnified 50 diameters.

The wood of southern prickly ash is moderately heavy, hard, close grained, with yellowish-brown heartwood and very thin yellow sapwood. The annual rings of growth can be distinguished with the naked eye, especially in samples from the temperate Zone, but they are less distinct in specimens from Cuba or extreme southern Florida. The early wood is marked by a single line of pores or vessels which vary from 0.1 to 0.15 millimeter in diameter. These vessels are usually somewhat larger than those formed later. Vessels in the late wood vary from 0.03 to 0.1 millimeter and are evenly distributed throughout the annual ring of growth; occasionally they are arranged radially in groups of from two to four. The perforations at the ends of the vessel segments resemble large simple pits. The side walls of vessels have bordered pits where they are in contact with the wood-parenchyma fibers or pith ray cells. The wood fibers which form the bulk of the secondary wood have simple pits and vary in length from 0.630 to 1.302 millimeters, with an average length of 0.939 millimeter. Wood-parenchyma fibers are not very abundant, occurring sparingly only near vessels and invariably contain small solitary crystals in each cell. The pith rays are very narrow, varying from one to three, but rarely more than two rows of cells in width. (Fig. 4.)

IDENTIFICATION OF FUSTIC WOOD AND ITS SUBSTITUTES.

The distinguishing characters of nearly all woods are more readily observed in transverse than in longitudinal sections, and for this reason the illustrations in this circular show magnified transverse sections of the wood of fustic, smoke-tree, osage orange, and southern prickly ash (figs. 1, 2, 3, and 4). It is chiefly upon the characters to be seen in these sections with an ordinary pocket lens that the following key is based:

A. Layers of growth indistinct (diffuse porous).[1]
  1. Tangential (wavy) bands of wood-parenchyma fibers[2] conspicuous, and containing numerous small pores filled with tyloses.
    (*a*) Wood light yellow, retaining color indefinitely, moderately hard and heavy (about 43 pounds per cubic foot). *Chlorophora tinctoria* (fig. 1).
B. Layers of growth distinct (ring-porous).[3]
  1. Tangential bands of wood parenchyma in the late wood more or less inconspicuous and interrupted.
    (*a*) Wood orange yellow (when freshly cut), turning brown with exposure, hard and heavy (48.2 pounds per cubic foot). The large pores in early wood are completely filled with tyloses. *Toxylon pomiferum* (fig. 2).
  2. Tangential bands of wood-parenchyma fibers entirely wanting.
    (*a*) Wood brownish yellow, moderately hard, and of lighter weight (about 40 pounds per cubic foot) than the preceding. Pores in early wood large and very numerous, gradually diminishing in size and number in the late wood........................*Cotinus cotinus* (fig. 3).
    (*b*) Wood pale yellow, slightly tinged with red, moderately hard, and of lighter weight (31.51 pounds per cubic foot) than the preceding. Pores in early wood smaller than in the preceding, forming a single interrupted row, abruptly diminishing to a slightly smaller size and evenly distributed in the late wood, solitary or in groups of two to four ....*Xanthoxylum clavaherculis.*

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[1] See footnote 1, p. 8.

[2] This tissue appears as fine lines or bands, usually wavy and often interrupted, running in the same direction as the annual layers of growth, and is seen in figure 1.

[3] See footnote 2, p. 8.

ANATOMICAL CHARACTERS OF FUSTIC WOOD.

A full description of the microscopic structure of fustic wood is presented here for the help it may give in distinguishing true fustic from possible new, and at present unknown, substitutes whose gross characters may not, as in the case of the osage orange, smoke-tree, and prickly ash, suffice for identification.

Fustic wood does not exhibit true annual rings of growth. The alternating bands of wood parenchyma and wood fibers are sometimes mistaken for such, the softer tissue appearing as early wood and the dense tissue as late wood. This error may be avoided, however, by remembering that early wood is never composed of tissue wholly different from that of the late wood. Moreover, the absence of an intermediate zone showing gradual transition from early to late wood is further evidence that these are not annual rings of growth.

A radial cut of true fustic wood made with a sharp knife shows alternating tangential bands of different tissues, which are quite conspicuous when viewed with a hand magnifier. Their prominence is due not so much to the difference in color as to the variation in density and character of the elements composing them. The main tissue, consisting of very hard, thick-walled wood fibers, forms dense undulating bands alternating with layers of less dense tissue composed of thin-walled wood-parenchyma fibers, and known as wood-parenchyma bands. These are seldom continuous around the stem or branch, but are very irregular, often quite short or meeting with the next inner or outer bands of similar tissue. They are from one-third to one-half the width of the bands of wood fibers alternating with them. The bands of wood fibers vary from 2 to 6 cells in width, except in regions of pores, where they are often from 10 to 12 cells wide. The pores lie within the bands of wood parenchyma and are wholly surrounded by them.

Vessels (transverse section)[1] vary from 0.02 to 0.25 millimeter in diameter, are more or less evenly distributed throughout the wood, and are easily seen with the aid of a pocket lens magnifying from 4 to 6 diameters. The walls are usually quite thick, especially on the side bordering other vessels. The vessels are wholly surrounded by wood-parenchyma fibers, and usually are much greater in diameter than the average width of the bands, which are thus rendered undulating. They are regularly distributed either singly, or less often in radial groups of 2 to 4, and are invariably filled with a yellowish mass called tyloses, which forms a network of cross walls within the vessel cavities. The vessel segments, which may, with aid of the microscope, be seen in longitudinal sections or in macerated material, are exceptionally short, seldom more than 0.5 millimeter long.

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[1] See description (fig. 1).

The end cross walls are wholly absorbed, leaving an open passage connecting the abutting segments. These end walls are usually horizontal, though there are exceptions, especially in segments of the largest vessels, which have more or less oblique ends, each with an elongated pointed projection extending along the side of the next segment above and below.

The walls of the vessels have bordered pits. Where vessels are in contact with wood-parenchyma fibers or pith-ray cells the pits are arranged in groups, and although they are bordered, at least in the walls of the vessel, a slight transition to large simple pits occasionally occurs in the adjoining elements. The pit canals are round on the outside of the vessel walls, but they gradually widen out laterally on the inner walls of the vessels into slitlike canals which communicate one with another. The small vessels, especially those resembling tracheids, have markings on their walls similar to those of vessels; spiral-like markings, such as are found in osage orange, are nowhere present in this species. True tracheids have not been found in this wood; all elements with small cavities and bordered pits have simple perforations, at least at one end, and are thus to be classed as parts of vessels.

Wood fibers[1] are arranged radially in regular rows. They have exceedingly thick walls, the cavities being almost entirely obscured. In the region of large pores, which by virtue of their rapid growth exert considerable lateral pressure, the wood fibers and wood-parenchyma fibers are flattened radially; otherwise they are either circular, oval, or polygonal. Wood fibers vary in length from 0.65 to 1.18 millimeters, with an average of 0.939 millimeter. They are often less than 0.02 millimeter in diameter, and are long acuminate at both ends. The markings on the cell walls are indistinct, the pits being simple, minute, and arranged in a single row, chiefly on the radial walls.

Wood-parenchyma fibers[1] are arranged in tangential bands forming structures which contrast strongly with the bands of harder tissue bordering on the outside and inside. In transverse section these elements are often twice as wide as the wood fibers, or about 0.04 millimeter, their walls much thinner, and their cavities relatively larger and invariably filled with a parenchymatous substance easily soluble in alkali. Wood-parenchyma fibers bordering vessels are generally compressed either in radial or tangential direction; elsewhere they are circular or polygonal. They are somewhat shorter than wood fibers, and are composed of from 3 to 8 wood-parenchyma cells (more often 3 to 5) having horizontal or sometimes slightly oblique cross walls. The walls of these elements are marked on all sides by simple pits. Crystals of calcium oxalate are exceedingly abundant in wood-parenchyma fibers,[1] especially in cells bordering pith rays. These polygonal crystals occur in perpendicular rows varying from few to 8 or 10.

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[1] See description (fig. 1).

Pith rays[2] are regularly distributed throughout the wood. They are from 1 to 3 cells wide and from few to 30 or more cells high. They range in height from 0.2 to 0.7 millimeter. In a tangential section the pith-ray cells may be observed to vary considerably in size. Within the layer of denser tissue the rays are very narrow and the cells are invariably compressed laterally; within the bands of wood-parenchyma the pith rays are broader and the cells composing them larger and perfectly round in transverse sections. Ray cells bordering wood-parenchyma fibers occasionally contain crystals of calcium oxalate, but these crystals, very numerous in this wood, are found mainly in wood-parenchyma fibers. The individual cells of such fibers are cubic, and are usually much larger than the ordinary wood-parenchyma cells. The sculpture of the walls of the pith-ray cells is similar to that of the cells of the wood-parenchyma fibers.

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[1] Parenchymatous elements containing crystal are known as idioblasts.

[2] See description (fig. 1).

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